

**RADIO STATION WITH CIRCULARLY POLARIZED ANTENNA
BACKGROUND OF THE INVENTION**

The present invention relates to a radio station, which can be used especially as a base station in cellular radiotelephony systems.

More particularly, the invention relates to a radio station, comprising several antennas associated with hybrid polarizing ^{couplers} ~~elements~~, respectively, each polarizing coupler having at least one input connected to radio signal processing means comprising at least one receiver and two outputs connected to the antenna which is associated therewith such that when said outputs deliver two quadrature radio signals, respectively, in response to a transmission signal received on one of the two inputs of the polarizing coupler, the antenna which is associated therewith generates two orthogonal electric field components forming a circularly polarized wave.

Document FR 2 746 991 discloses an arrangement of antennas in a radio station, the antennas transmitting a circularly polarized field. On reception, the waves picked up in order to produce the processed signals are linearly polarized. The receiver provides spatial diversity processing and linear polarization diversity processing in order to counteract channel fading.

In order to separate the transmitting and receiving paths, the antennas of the radiocommunication stations are associated with duplexers. In the case of circularly polarized antennas of the type described in FR 2 746 991, these duplexers are connected between the antenna ^{and} the polarizing coupler.

Documents EP 0 449 492 and "Base Station/Vehicular Antenna Design Techniques Employed in High-Capacity Land Mobile Communications System" (Y. Yamada et al, Review of the Electrical Communications Laboratories, Vol. 35, No. 2, 1st March 1987, pages 115-121), WO 96/28944 and WO 97/37441,

disclose a base station comprising antennas which are distributed in a defined geometric configuration so as to transmit a circularly polarized field.

In addition, document WO 96/28944 and
5 WO 97/37441 disclose receiving means which are intended to provide circular polarization diversity processing.

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The aim of the present invention is, in particular, to propose other arrangements of antennas in radio stations, so as to obtain high performance in
10 reception and/or to simplify its design and its construction.

To this end, in a radio station of the type indicated in the introduction, the receiver is arranged so as to combine several input radio signals obtained
15 from respective inputs of the hybrid polarizing couplers, and the antennas are placed so as to radiate toward diametrically opposite sectors.

By virtue of this simple station design, the receiver processes several signals picked up on
20 diametrically opposite sectors, these signals being obtained by mixing, in the hybrid couplers, different components of the electric field picked up by the antenna. The result of this is some smoothing of the perturbations which can affect these components, and
25 therefore less sensitivity of the receiver to these perturbations.

Preferably, at least one of the hybrid polarizing couplers has two inputs, from which two input radio signals supplied to the receiver are
30 respectively obtained, the receiver then being arranged so as to provide diversity processing based on said input radio signals. In this way, another form of polarization diversity is obtained in reception. Advantageously, this version makes it possible to
35 counteract the fading effects, especially when the propagation medium creates relatively little diversity.

Where one or more duplexers are required, each of them can be connected between an input of the polarizing coupler, an input of the receiver and the

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With reference to all of figures 1 to 6, the radio stations according to the invention described

here by way of example comprise either one antenna 1,
or two antennas 1 and 2. Each antenna consists, for
example, of two coplanar dipoles P1, P2 oriented
perpendicularly to each other. By way of example, the
5 dipole P1 may be placed horizontally and the dipole P2
vertically.

Each antenna 1, 2 is associated with a
respective hybrid polarizing coupler 3_1 , 3_2 . Each of
these couplers 3_1 , 3_2 has two inputs A1, A2 and B1, B2
10 and two outputs, one, C1, C2 driving the dipole P1 of
its associated antenna 1, 2, the other D1, D2 driving
the dipole P2 of its associated antenna 1, 2.

Each polarizing coupler 3_1 , 3_2 is chosen so that
it produces two quadrature radio signals on its two
15 outputs C1 and D1, C2 and D2. To this end, hybrid
couplers, called "branch line" couplers, are used, as
in patent application WO 97/37440, to which reference
can be made.

The components delivered by the outputs Ci and
20 Di of the coupler 3_i are thus still in quadrature one
with respect to the other, such that when they drive
the dipoles P1, P2 respectively of the associated
antenna, the latter generates two orthogonal electric
field components forming a circularly polarized wave.
25 The left or right direction of the circular
polarization depends on the polarization of the inputs
Ai, Bi of the coupler from which the transmitted signal
comes. Consider, for example, the case where a signal
driving the input Ai of the coupler 3_i generates a left
30 circularly polarized (LCP) wave, while a signal driving
the other input Bi of the coupler 3_i generates a right
circularly polarized (RCP) wave.

In the exemplary embodiment shown in figure 1,
where the radio station comprises one antenna 1
35 associated with a hybrid polarizing coupler 3_1 , the
polarizing coupler 3_1 has its input A1 connected, via a
duplexer 4_1 , to a radio signal source or transmitter T1
forming part of a transmitting-receiving unit TR1, and

its input B1 connected to an input F1 of a receiver R1 forming part of said transmitting-receiving unit.

With the aim of providing circular polarization diversity processing, the duplexer 4₁ supplies a second
5 radio signal to another input E1 of the radio signal receiver R1. The duplexer 4₁, associated with the polarizing coupler 3₁, separates the transmitting and receiving paths.

This arrangement of the duplexer has the
10 advantage, compared to the arrangement which is adopted in the radio stations of the type described in WO 97/37440, of being able to house the transmitting-receiving unit, together with the duplexer 4₁, in the main housing 6 of the radio station, which is shown in
15 dotted lines in figure 1, the antenna 1 and the hybrid coupler 3₁ then being outside this housing. Consequently, the station installer will have much more freedom with regard to the design and choice of antennas. He will also be able to choose to integrate
20 the duplexer into a microwave circuit providing other functions, such as filtering, so as to limit the costs of the radio stage.

In the exemplary embodiment shown in figure 2, the radio station comprises another antenna 2 which is
25 associated in a similar manner with another hybrid polarizing coupler 3₂. The antennas 1 and 2 are placed so as to radiate toward the same sector of space.

In the layout of figure 2, the polarizing coupler 3₁ still has its input A1 connected, this time
30 directly, to the radio signal source T1, and its input B1 connected to the input E1 of the receiver R1. As for the polarizing coupler 3₂, it has its input A2 connected by a coaxial cable to the input F1 of the receiver R1. Its other input B2 is connected to a resistor 10 for
35 impedance matching.

The presence of the two antennas 1 and 2 in the radio station makes it possible to combine the advantages of spatial diversity and of circularly polarized diversity in the two input signals of the

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receiver R1. This is due to the fact that the radio signals supplied to the inputs E1, F1 of the receiver R1 come from non-homologous inputs B1, A2 of the polarizing couplers.

5 In the variant of figure 3, the signals
processed by the receiver R1 come from homologous
inputs B1, B2 of the two couplers such that the
diversity processing applied by the receiver R1 only
gives spatial diversity, possibly associated with a
10 gain in directivity.

The layout of figure 2 or 3 is advantageous in the sense that a duplexer no longer has to be provided to separate the transmitting and receiving paths. However, depending on the performance of the coupler used and on the standing wave ratio of the antenna in the circular polarization direction used for the transmission, filters (not shown), which are smaller and less expensive than duplexers, will possibly be provided upstream of the inputs E1 and F1 of the receiver R1, in order to remove the components coupling with the powerful transmission signal.

In the embodiment shown in figure 4, the radio station comprises a single antenna 1 associated with a polarizing coupler 3₁, and two transmitting-receiving units TR1, TR2, with a radio signal source T1, T2 and a diversity receiver R1, R2. The advantages outlined above can be fully obtained for the two transmitting-receiving units TR1, TR2.

In the layout shown, the inputs A1 and B1 of the polarizing coupler 3₁ are connected to the radio signal sources T1, T2, respectively, via a corresponding duplexer 4₁, 4₂. In addition, the input A1 of the polarizing coupler 3₁ is connected by a coaxial cable, via the duplexer 4₁, to an input I1 of a division module 5₁ which is included in the main housing 6 of the radio station and which is, for example, a coupler of the "Wilkinson" type, while the other input B1 of the coupler 3₁ is in addition connected by a coaxial cable, via the duplexer 4₂, to an input I2 of a division module

5₂, which is identical to the module 5₁. The division module 5₁ has two outputs G₁, H₁, one of which, G₁, is connected to the input E₂ of the receiver R₂ and the other of which, H₁, is connected to the input E₁ of the receiver R₁. The division module 5₂ also has two outputs G₂, H₂, one of which, G₂, is connected to the input F₂ of the receiver R₂ and the other of which, H₂, is connected to the input F₁ of the receiver R₁. This embodiment has the additional advantage of obtaining, with only one antenna 1, a gain in polarization diversity for each of the two receivers R₁ and R₂. In this case too, the duplexers can be housed in the main housing 6 of the station.

The exemplary embodiment shown in figure 5 combines the advantages of the embodiments shown respectively in figures 2 and 4. In this example, there are two antennas but no duplexers. The inputs A₁ and B₂ of the polarizing couplers 3₁ and 3₂ are connected directly to the radio signal sources T₁ and T₂. As for the other inputs B₁ and A₂ of these polarizing couplers, they are connected to division modules 5₁ and 5₂, respectively, which are for example of the same type as those mentioned above. The division module 5₁ has its outputs G₁, H₁ connected to the input E₁ of the receiver R₁ and to the input E₂ of the receiver R₂, respectively, while the division module 5₂ has its outputs G₂, H₂ connected to the input F₁ of the receiver R₁ and to the input F₂ of the receiver R₂, respectively. This embodiment thus gives a gain in spatial and polarizing diversity for each of the two receivers R₁ and R₂ if the two antennas radiate toward the same sector of space.

An arrangement such as that of figure 5 can also be used in cells of elongate shape such as those which go along railroads or main highways. In this case, the two antennas 1, 2 are placed head to tail, so as to radiate toward two diametrically opposite sectors.

It should also be noted that, in this example, the station installer has the freedom of choosing the

option of a gain in receiving directivity instead of a gain in polarizing diversity. For this, it will be enough, for example, for him to reverse the connection of the coaxial cable which connects the input A2 of the coupler 3₂ to the output I2 of the division module 5₂ with the connection of the coaxial cable which connects the input B2 of the polarizing coupler 3₂ to the radio signal source T2.

In the example shown in figure 6, the radio station comprises two antennas 1, 2 associated respectively with two polarizing couplers 3₁ and 3₂, two duplexers 4₁ and 4₂, four transmitting-receiving units TR1, TR2, TR3 and TR4 and two division modules 5'₁ and 5'₂. The division modules 5'₁ and 5'₂ have a structure similar to that of the division modules 5₁ and 5₂ mentioned above, with the one difference that they have four outputs G'1, H'2, J'1, K'1 and G'2, H'2, J'2, K'2, respectively, instead of two outputs. Each one may, for example, consist of three "Wilkinson" couplers arranged in two steps. The inputs A1, B1 of the polarizing coupler 3₁ are connected to the radio signal sources T1, T2, respectively, while the inputs A2, B2 of the polarizing coupler 3₂ are connected to the radio signal sources T3, T4, respectively. The duplexer 4₁ is connected between the input A1 of the polarizing coupler 3₁, the radio signal source T1 and the input I'1 of the division module 5'₁, while the duplexer 4₂ is connected between the input B2 of the polarizing coupler 3₂, the radio signal source T4 and the input I'2 of the division module 5'₂. The four outputs G'1, H'1, J'1, K'1 of the division module 5'₁ are connected respectively to the inputs E4 of the receiver R4, E3 of the receiver R3, E2 of the receiver R2 and F1 of the receiver R1, while the four outputs G'2, H'2, J'2, K'2 of the division module 5'₂ are connected respectively to the inputs E1 of the receiver R1, F2 of the receiver R2, F3 of the receiver R3 and F4 of the receiver R4. It is thus possible with this embodiment to increase even further the gain in polarizing diversity for the four

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